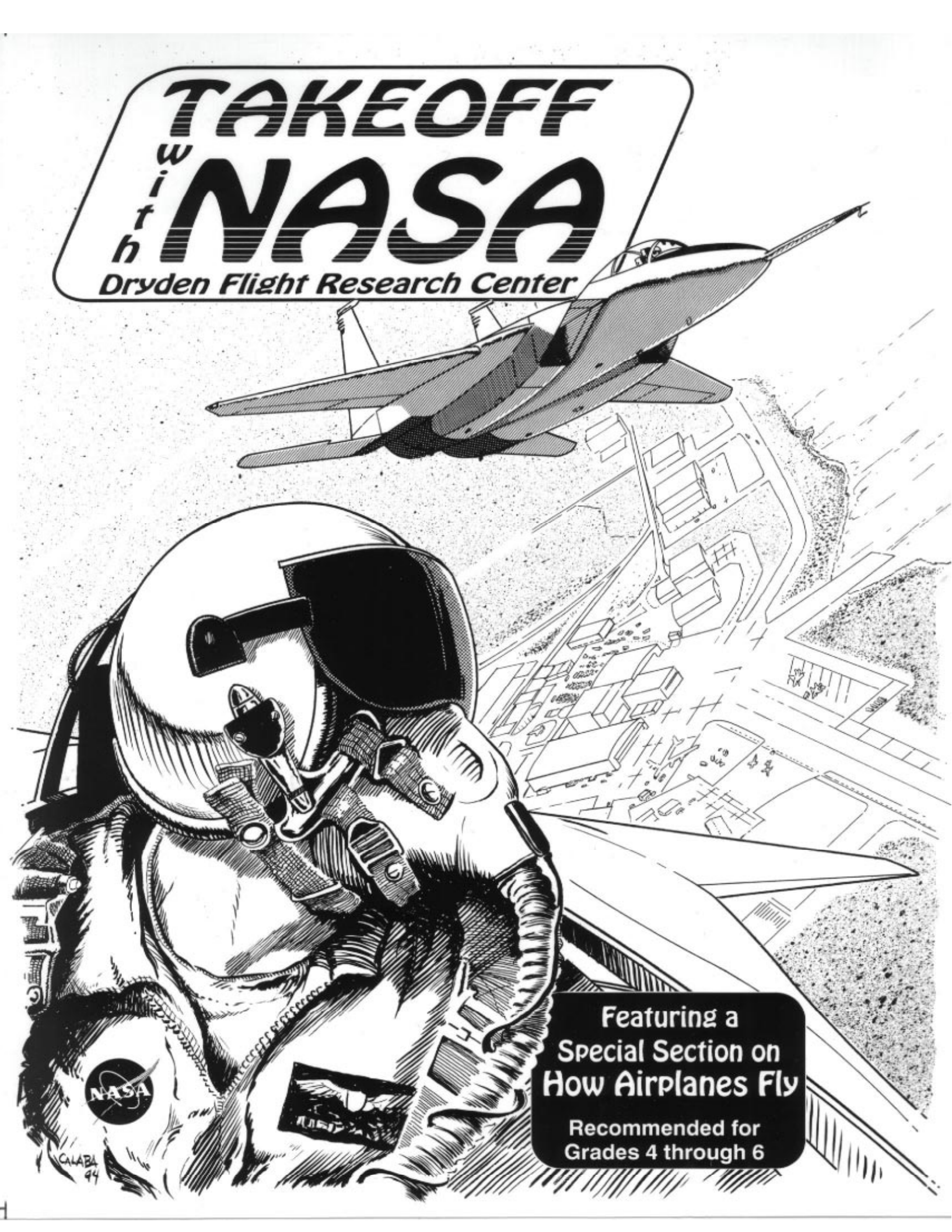
TAKEOFF with NASA

Dryden Flight Research Center



Featuring a Special Section on How Airplanes Fly

Recommended for Grades 4 through 6

The Dryden Flight Research Center

is NASA's premier installation for aero–nautical flight research. It is located within the boundaries of Edwards Air Force Base on the western edge of the Mojave Desert, 80 miles north of metropolitan Los Angeles. Guided tours of the facility are offered twice daily, Monday through Friday, (except for federal holidays and shuttle landing days).

To make an individual or group reservation for a tour, call (805) 258-3446 or 258-3460 during office hours, 7:30 a.m. to 4:00 p.m. Monday through Friday.

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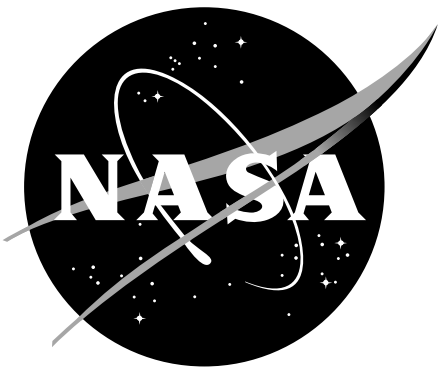


The Story of NASA Dryden

Dryden is part of the National Aeronautics and Space Administration (NASA). It is one of the world's most famous places to test airplanes and carry out research to help make airplanes safer, better, and use less fuel.

Dryden has been at Edwards Air Force Base since 1946. That is when the first group of NASA people arrived to begin testing the X-1 airplane. The X-1 was powered by a rocket engine and was the first airplane to fly supersonically, or faster than the speed of sound (about 720 miles per hour). The pilot on the first supersonic flight was Chuck Yeager. Until then, scientists thought that airplanes would come apart in the air if they went faster than the speed of sound. Now airplanes, including passenger transports, fly faster than sound every day.

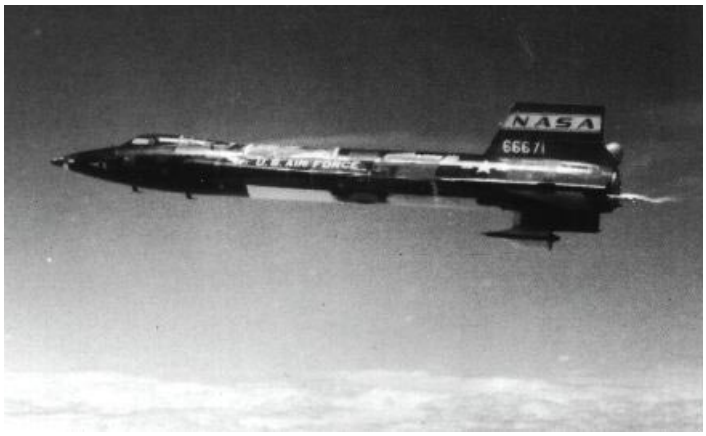
The X-1 was the first of a long series of experimental (called "X") airplanes. Since then, Dryden has developed and tested many important designs now used on airplanes. Some of the designs tested include swept wings, the first all-electronic control system, and improvements on the wings to help make airplanes fly faster and use less fuel.

Another experimental rocket airplane flown at Dryden, the X-15, set the world's records for speed and altitude, flying 4,520 miles an hour and 354,000 feet high.

The X-15 was carried into the sky by a B-52 mothership. The X-15 hung from a wing pylon mount on the B-52, and its rocket engine was lit after it was released from the mothership. The same B-52 was used to drop many other research and test airplanes at Dryden. The airplanes helped in the design of the space shuttles and for many other inportant projects. The B-52 is still flown today for a variety of projects.

In the 1970's, NASA tested an early model of the space shuttle at Dryden to make sure it could be controlled as it came back to Earth and landed on a regular runway. The test space shuttle, called Enterprise, was put "piggyback" on top of a big 747 passenger airplane and flown up into the air and released. Many times the space shuttle test pilots flew Enterprise like a glider and safely landed it on the dry lakebed and also on the main runway at Edwards. These tests proved that the space shuttle was ready to be launched into space and come back safely.

Above, X-1



Below, X-15

Below, "Piggyback ride"

Dryden used to be where all the space shuttles landed. Now most of the space shuttle flights end where they begin —at the Kennedy Space Center in Florida. Dryden is still the backup landing site when the space shuttles can't land in Florida because of bad weather.

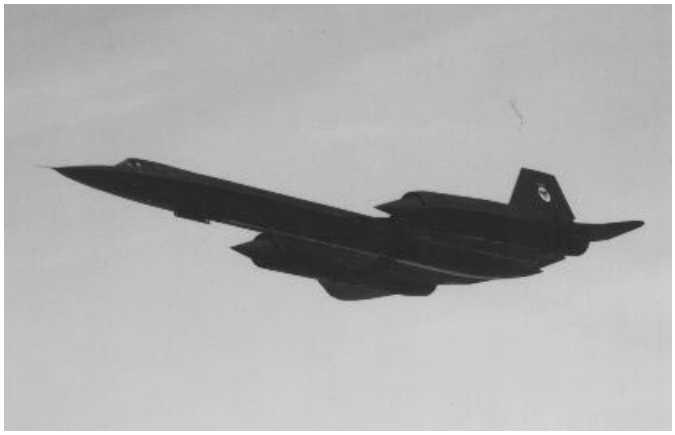
To lift the space shuttles on to the back of the 747 shuttle carrier aircraft, NASA built what is called the Mate-Demate Device (MDD). It's like an Erector Set tower and is located next to a special space shuttle hangar at Dryden.

After space shuttles land at Dryden, they are ferried "piggyback" on the 747 back to the Kennedy Space Center where they get ready for their next space flight.

In the early 1970s, Dryden began flying small remotely

piloted airplanes with a radio-controlled system. It's just like flying large model airplanes with remote controls, only Dryden does it when the tests can be very dangerous to a pilot or when it's cheaper to use the model instead of a large airplane with a pilot. Alot of information was obtained this way about how to make airplanes stronger, lighter in weight, and how to make them fly safer.

Dryden pilots learned how to fly the remotely-controlled test airplanes from a ground cockpit by practicing with a Piper PA-30 Comanche, a two-engine airplane modified to be flown without a pilot.



SR-71, the Blackbird

MDD, Shuttle, 747

Landing at Dryden

The radio control system and PA-30 are still at Dryden and these types of tests may be carried out again to develop newer ways to make airplanes fly better and safer.

Today, many exciting things are happening in aviation at Dryden. Three SR-71 Blackbirds are flying to help scientists learn more about the atmosphere and astronomy, and also to help test ideas and things that will be used on new models of high-speed civilian transports. The SR-71 Blackbird was once flown as a spy (reconnaissance) airplane by the U.S. Air Force. The SR-71s fly more than 2,200 miles an hour and go more than 80,000 feet up in the sky. They fly higher and faster than any airplane in the world today. Now that the U.S. Air Force is not using the SR-71s, NASA flies them for projects where high speeds and high altitudes are needed.

One airplane being tested at Dryden will help make fighter jets of tomorrow turn quicker and fly safer and easier. It is the X-31, which uses paddles around the exhaust nozzle to change the direction of the exhaust flow. This concept is called thrust vectoring and helps pilots maneuver their airplane in tight turns. The X-31 is the newest "X" (experimental) airplane, and is being tested by a group of people called the International Test Organization. These people are from NASA, Rockwell International (the designers and builders of the X-31), the German Air Force, the German government, and the U.S. Defense Department.

The NASA Dryden Research Center

Another type of airplane at Dryden is an F-18. It also uses paddles around its exhaust, but for a different reason than the X-31. It uses paddles to help it fly steeper for long periods of time so that scientists can study the flow of air over the wings and body. Information from these tests will help designers build more maneuverable airplanes in the future.

Dryden also uses several other F-18s as support airplanes. Pilots in the support airplanes — also called "chase" planes — watch the tests and are like "another set of eyes in the sky" to make sure the tests are being carried out safely. Photographers also ride in chase planes to take pictures of the tests using an F-16XL airplane.

A big project at Dryden may some day help make future jet transports cheaper to fly. The project is called Laminar Flow. It is the study of air flowing over an airplane wing. The goal of the project is to smooth out the rough air as it passes over the wing. It takes less fuel and money to fly an airplane if the air going over the wing is smooth. Airplane tickets may cost less if new transports have laminar flow over their wings.

It takes many men and women at Dryden to fly and support the test and research airplanes of NASA. In addition to pilots, people work as aircraft mechanics, electronics and electrical technicians, designers, engineers, computer technicians and operators, facilities maintenance specialists, photographers, radio operators, and mathematicians.

A sampling of Dryden's aircraft fleet

The work being done today at Dryden will be seen in the many airplanes flying over the entire world in the years to come. Now, let's **"Takeoff With NASA."** This workbook will help you learn about airplanes and how they fly.

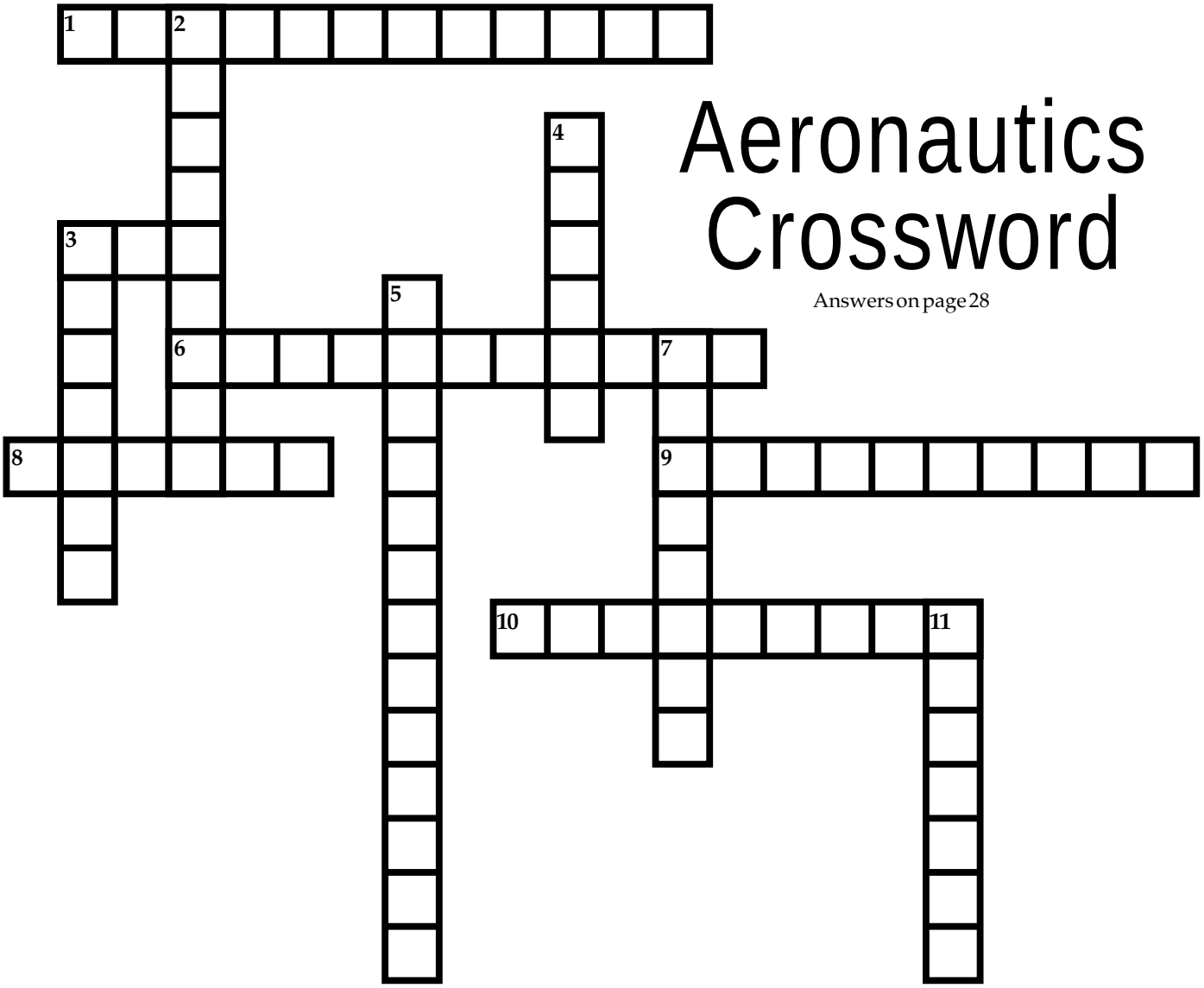
X-31

F-18

F-16XL

Aeronautics Crossword

Answers on page 28



Across

1. The Bell X-1 was this type of aircraft.
3. The SR-71 was used as what kind of plane when the Air Force flew it?
6. The first A in NASA stands for ?
8. This kind of engine powered the X-15.
9. This plane launches other research aircraft.
10. The SR-71's nickname.

Down

2. The 747 carries the shuttle this way.
3. Dryden uses the F-18 aircraft for this purpose.
4. Another word for laminar.
5. The X-31 is an ? test project.
7. This Piper aircraft is used to train pilots to fly aircraft by remote control.
11. The shuttle can land on the runway at Edwards or on the ?

Word Box

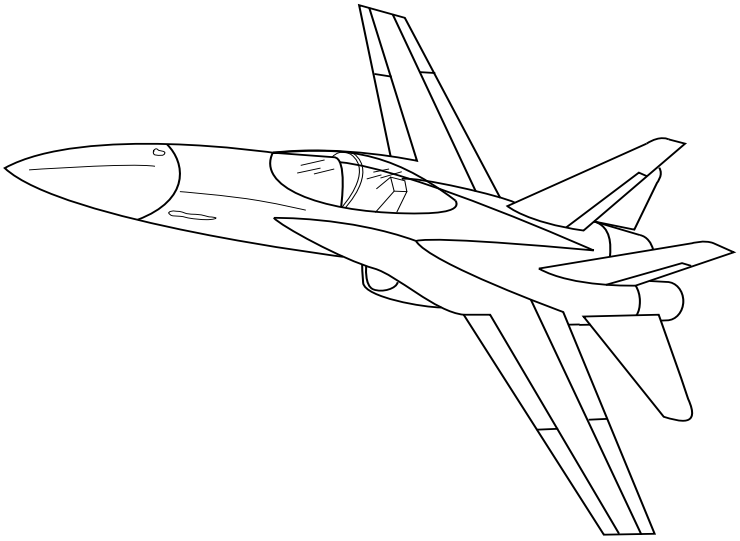
Support	Rocket	International
Piggyback	Experimental	Comanche
Drylake	Aeronautics	Blackbird
Spy	Smooth	Mothership

Let's Go To Dryden!

Read the story. Then circle the correct answer to each question.

Mrs. Campbell's class was going to the NASA Dryden Flight Research Center for a field trip. The day started at school with Mrs. Campbell calling roll and collecting everyone's permission slips for the trip. Next, Mrs. Campbell put the students in groups of five with a parent as a chaperone. The students lined up and boarded the bus. Michelle and Mike sat together for the trip. The bus drove through the brown desert to NASA. Mike spotted a rabbit hopping through the creosote bushes.

Once the bus arrived at NASA, Mrs. Campbell's class filed into a big auditorium to watch a movie. The movie was fun. It showed them all of the airplanes that the Dryden Center tested. After the movie, the students listened closely to the rules for the tour. Soon they would see the airplanes up close! The tour guide led the class through two hangars full of airplanes. The class saw fighter planes, experimental planes, a bomber, and even a spy plane, all doing research at NASA. After the tour, the class had lunch in the NASA cafeteria and shopped in the gift shop. On the ride back to school, Michelle whispered to Mike, "I want to be a pilot when I grow up."

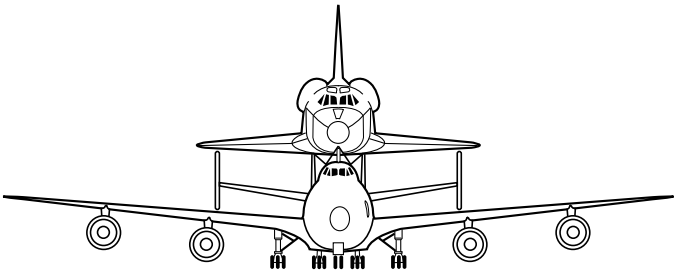


1. What happened first?

a. The students formed groups of five.
b. Parents came along as chaperones.
c. Mrs. Campbell called roll.
d. The class left for their field trip.

2. What happened just after the students boarded the bus?

a. Mike spotted a rabbit in the desert.
b. The class filed into a big auditorium.
c. The bus drove through the desert.
d. Michelle and Mike sat together.



3. What happened just before the tour guide led the students through the hangars?

a. The students listened to the tour rules.
b. The students watched a movie.
c. The students saw experimental planes and fighter planes.
d. The students filed into the auditorium.

4. What happened last?

a. The class shopped in the gift shop
.b. Michelle whispered to Mike
.c. The class rode the bus back to school.
d. The class had lunch.

Alphabetical Airplanes

Ted wanted to put the names of airplanes that he saw at NASA into his computer. He asked the computer to put the names in alphabetical order. How would the computer print out his list?

Talon(T-38)

Falcon(F-16)

Blackbird(SR-71)

JetStar

Convair 990

Boeing 747

HARV(F-18)

Eagle(F-15)

Starfighter(F-104)

Grumman X-29

Scale model F-15

X-15

Bell X-1E

Lifting body(HL-10)

Hornet(F-18)

Crusader(F-8)

Stratofortress(B-52)

Comanche(PA-30)

X-31

Computer printout:

1 _____ 6 _____ 11 _____ 16 _____

2 _____ 7 _____ 12 _____ 17 _____

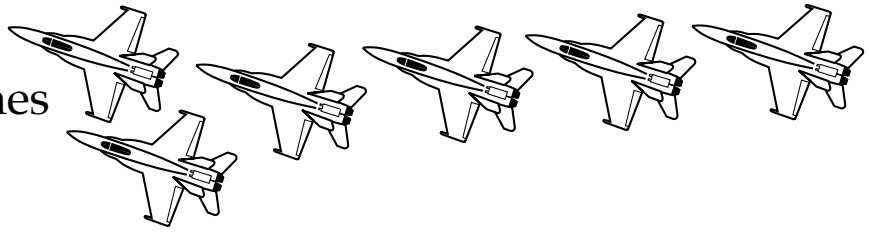
3 _____ 8 _____ 13 _____ 18 _____

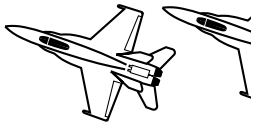
4 _____ 9 _____ 14 _____ 19 _____

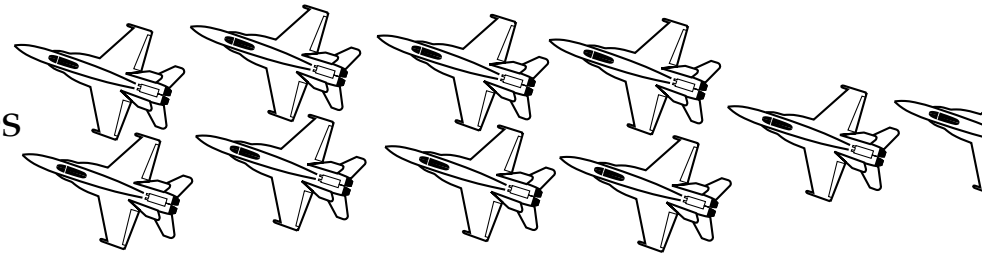
5 _____ 10 _____ 15 _____

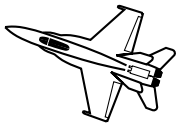
Airplanes at the Dryden Flight Research Center

(Each  equals two airplanes)

Chase & support airplanes 

Former passenger/airliner aircraft 

Research airplanes 

Remotely controlled airplanes 

Use the pictograph above to answer these questions:

1. How many airplanes does  stand for in the graph?_____

2. What kind of airplanes does NASA Dryden fly fewest of?_____

3. How many research airplanes does the facility fly?_____

4. How many chase airplanes are flown?_____

5. Does the facility fly more airliners or research planes?_____

6. How many remotely controlled airplanes are at the facility?_____

7. How many airplanes does the facility have in all?_____

What the Satellite Saw Going Over NASA Dryden

Many satellites orbiting Earth have cameras that take pictures of things on the ground. To get the pictures, the satellites send back coded radio signals. The signals go into a computer which turns the coded information into tiny dots called pixels. These pixels are then printed out to make the original picture.

Use the graph on the opposite page to see what the satellite camera saw when it passed over the NASA Dryden Flight Research Center. To make the picture, fill in the numbered squares on each alphabetical line. Good luck!

L - 62 to 63

M - 60 to 64

N - 58 to 64

O - 56 to 65

P - 54 to 65

Q - 52 to 66

R - 46 to 66

S - 44 to 65

T - 40 to 65

U - 38 to 65

V - 40 to 65

W - 43 to 65

X - 42 to 66

Y - 40 to 67

Z - 38 to 67

AZ - 16 to 68

AA - 11 to 35
42, 43
49 to 56
63, 64, 65
67, 68

BB - 8 to 35
37 to 43
45 to 48
50 to 60
63, 64
67 to 69

CC - 6 to 35
42, 43
49, 50, 51
55 to 59
62 to 65
67 to 71

DD - 8 to 40
42, 43
45, 46
49 to 58
61 to 65
67 to 69

EE - 11 to 35
42, 43
45, 46, 47
50 to 57
60 to 65
67, 68

FF - 16 to 68

GG - 38 to 67

HH - 40 to 67

II - 42 to 66

JJ - 43 to 65

KK - 40 to 65

LL - 38 to 65

MM - 40 to 65

NN - 44 to 65

OO - 46 to 66

PP - 52 to 66

QQ - 54 to 65

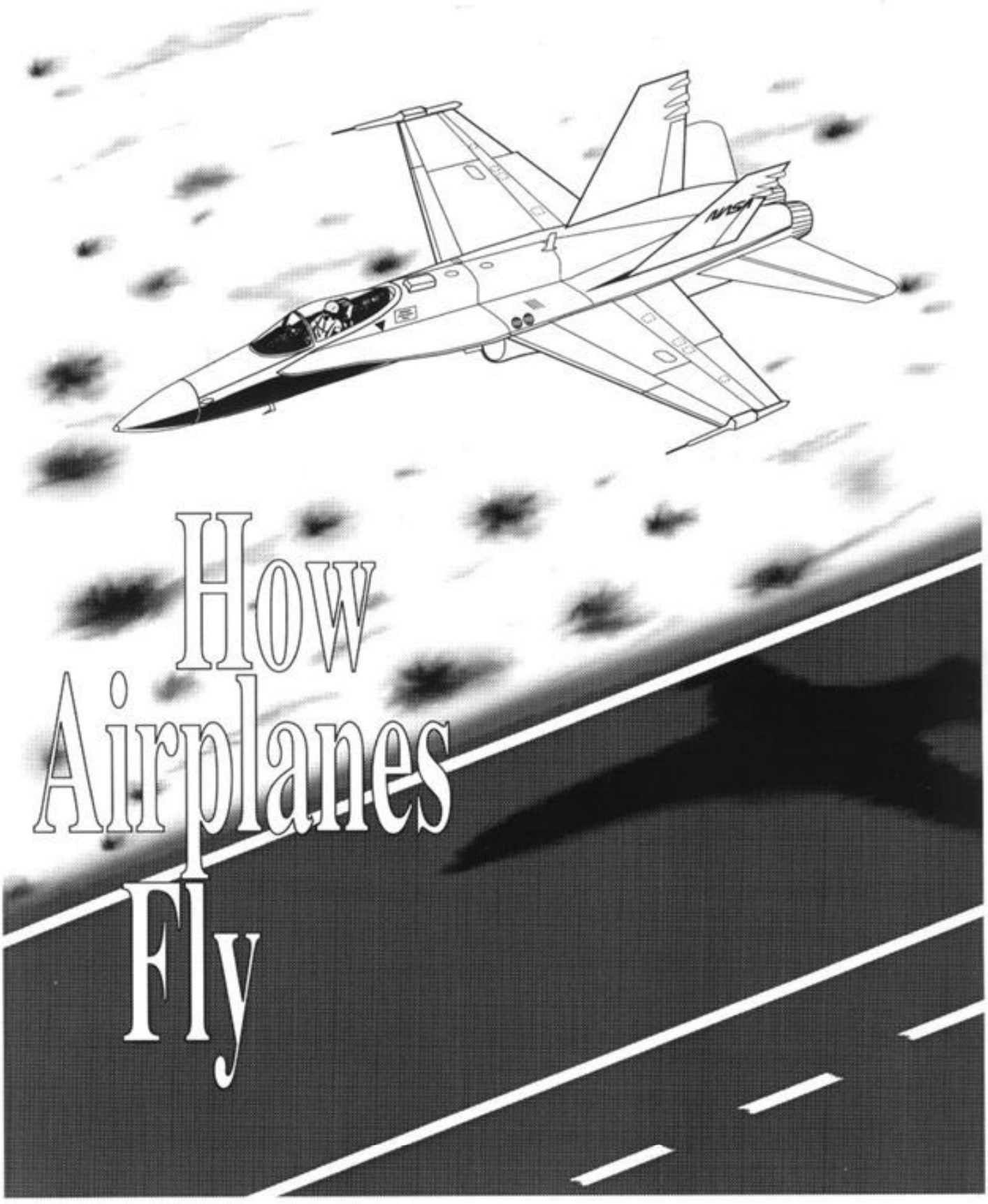
RR - 56 to 65

SS - 58 to 64

TT - 60 to 64

UU - 62 to 63

SR-71
grid


How
Airplanes
Fly

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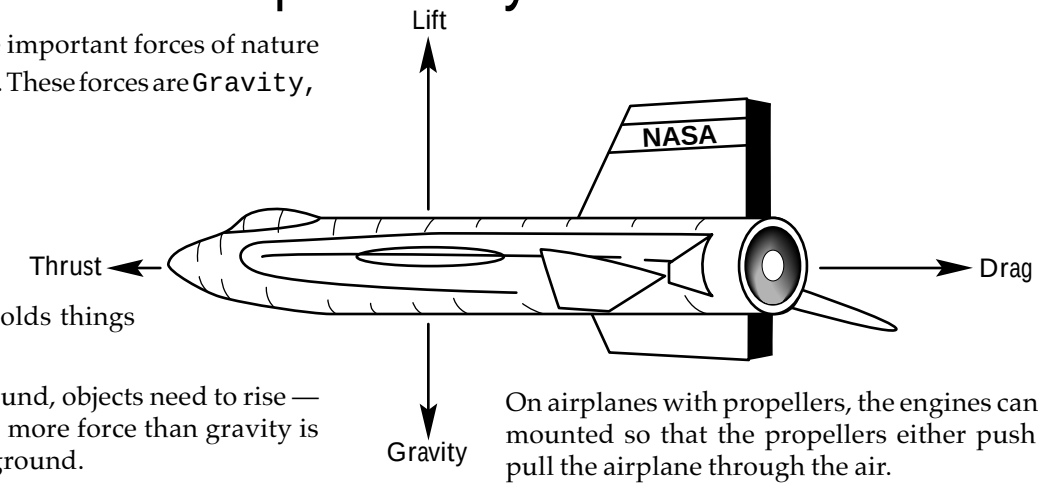
How Airplanes Fly

We must first learn about some important forces of nature to understand how airplanes fly. These forces are `Gravity`, `Lift`, `Thrust`, and `Drag`.



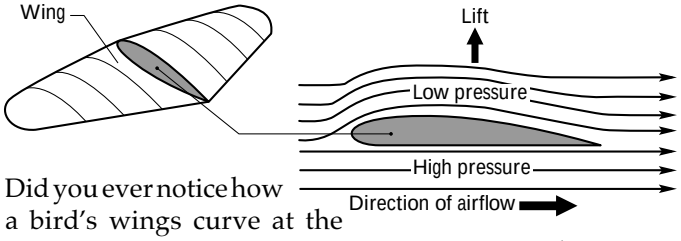
Gravity

The force that pulls everything toward the ground and holds things there is **gravity.**

To get off the ground, objects need to rise — or go up — with more force than gravity is using to pull them back to the ground.

Lift

Airplane wings create **lift.** The lift created by wings is stronger than the force of gravity holding the airplane on the ground.



Did you ever notice how a bird's wings curve at the top? An airplane's wing is curved too, just like the wings of a bird. The curved surface makes the air travel faster going over the top. It also means that the air flowing across the bottom of the wing is going slower than the air flowing across the top. This difference in airspeed creates less air pressure on the top of the wing and causes the wing to rise…and this is called lift. Lift created by the wing is stronger than the gravity trying to hold the airplane on the ground and the airplane is able to fly.

Thrust

Thrust is the pushing or pulling force of an aircraft engine that gives it the forward motion through the air to create lift.

Airplanes today get their thrust from propellers, turned by either a piston or turbojet engine, or from a pure jet engine. Rocket engines produce thrust, but they are used only on spacecraft, missiles, and experimental aircraft.

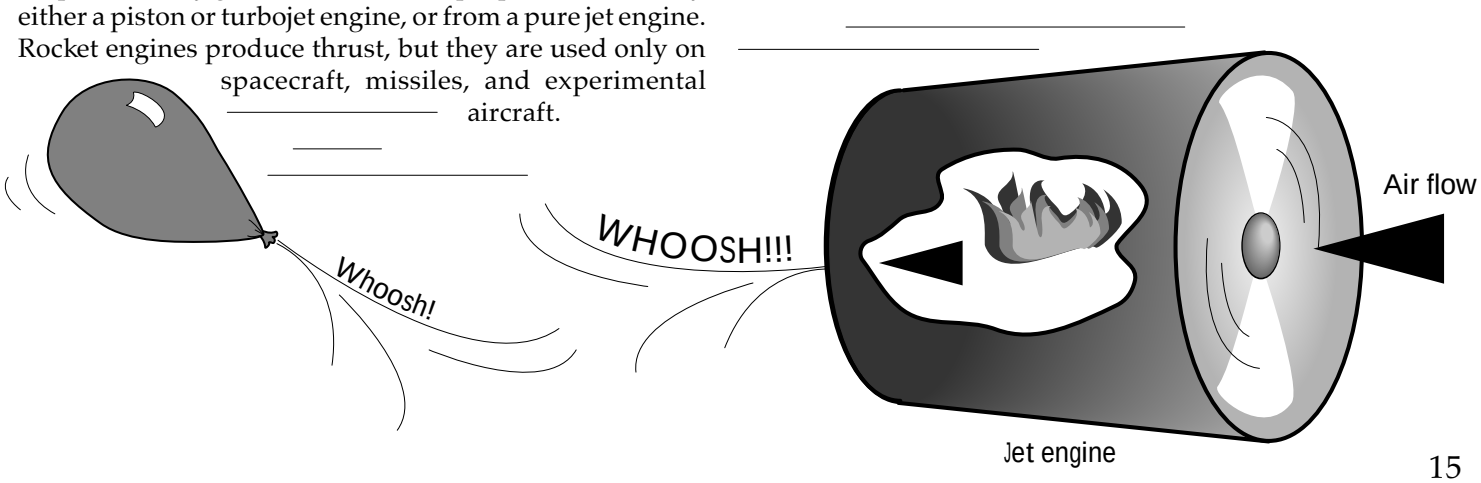
On airplanes with propellers, the engines can be mounted so that the propellers either push or pull the airplane through the air.

Propellers are curved on the top and flat on the bottom, just like wings. When propellers are turned by the engine, they act like small wings and create lift in a forward direction, which is called thrust.

The NASA *PA-30 Comanche* in the picture has two engines and two propellers.

The speed of an airplane with propellers is controlled by changing the speed of the engine. The faster the engine is turning the propeller, the faster the airplane flies.

Jet engines create more thrust than engines that turn propellers. Military fighters and most passenger airplanes use jet engines for power because they make airplanes fly faster and higher than airplanes with propellers.



In a jet engine, air flows in the front of the engine and is mixed with fuel and compressed. A spark plug makes the fuel mixture burn, expand, and rush out the exhaust nozzle at the back of the engine to make the airplane go forward. A jet engine's action can be compared to air escaping from a balloon. The balloon gets pushed forward when air is released from its nozzle.

In an airplane with a jet engine the speed is controlled by the flow of fuel into the engine. The faster the fuel burns, expands, and pushes out the exhaust nozzle, the faster the airplane is pushed through the air.

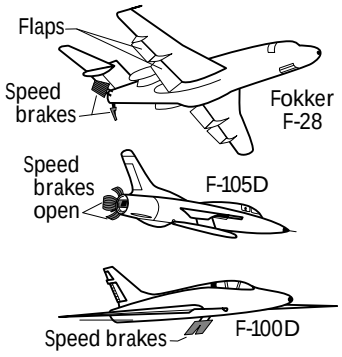
Drag

When an airplane is flying, the air flowing over the surfaces creates a friction or resistance. This resistance is called **drag** and it slows down the airplane. If there is enough drag on an airplane, it will not move forward fast enough to fly.

Almost every part on the outside of an airplane creates drag. That's why some airplanes have a streamlined main body or fuselage. A streamlined shape helps reduce drag. If airplane designers can eliminate drag, airplanes would use less fuel and could fly farther and faster.

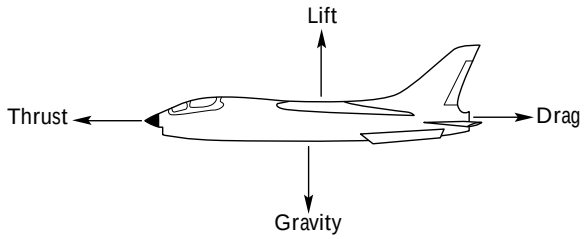
To fly, an airplane must have enough thrust to overcome its drag.

Most airplanes have movable panels on the rear edge of the wings, usually one on each side, called flaps. They can be lowered to cause drag and slow down the airplane on purpose. Flaps are also lowered to increase lift and are used during takeoffs and landings.



Some airplanes have speed brakes. They are moveable panels that extend out into the airstream to create drag and help slow down the airplane when it's landing. Look at the photo of the NASA F-15 and see if you can find the open speed brake. Compare the speed brake on the NASA F-15 with the speed brakes on the airplanes in the drawing.

F-15

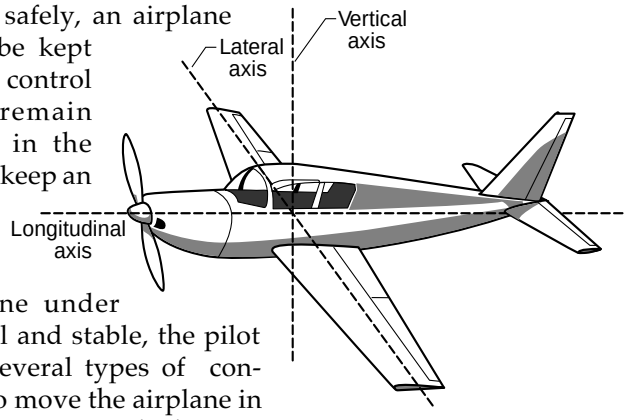


A Review of the Four Forces of Nature That Act on an Airplane

An airplane will fly if its wings create enough **lift** to overcome the force of **gravity,** which is trying to keep it on the ground…and if the engines produce enough **thrust** — and forward motion — to overcome the force of **drag.**

What Makes Airplanes Move?

To fly safely, an airplane must be kept under control and remain stable in the air. To keep an airplane under control and stable, the pilot uses several types of controls to move the airplane in three directions which are called axes.

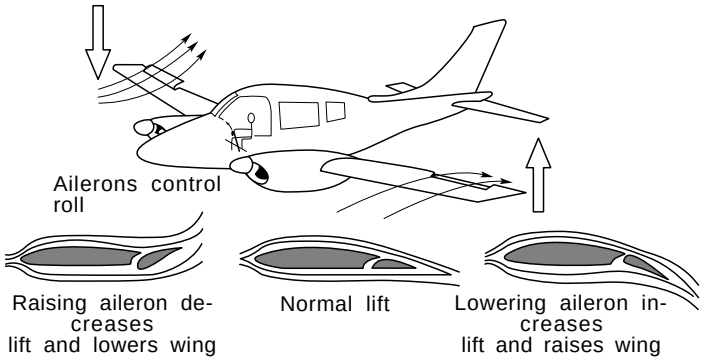


These axes are (1) longitudinal (length), (2) lateral (width), and (3) vertical (height).

Rolls

An airplane's longitudinal axis extends from the nose to the tail and it **"rolls"** on this axis. To control rolls, there is a small panel on the rear edge of each wingtip. These hinged panels are called *ailerons.* On most airplanes they are linked by cables, rods, and wires to the controls used by the pilot in the cockpit.

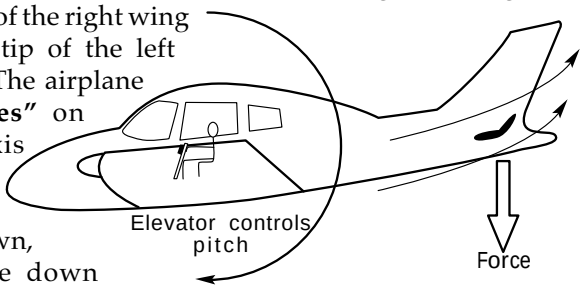
When the pilot moves the control wheel or control stick to the left this action causes the aileron on the left wing to raise up, which forces that wing down. At the same time, the right wing's aileron is lowered, causing that wing to rise

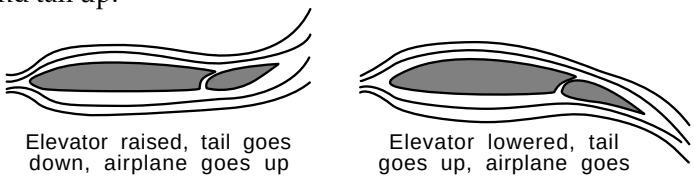


and the airplane rolls to the left. If the control wheel or stick is moved to the right, the left wing rises and the right wing is lowered, and the airplane rolls to the right. The ailerons are used to help turn an airplane left and right.

Pitch

An airplane's lateral axis extends through the wings, from the tip of the right wing to the tip of the left wing. The airplane **"pitches"** on this axis — nose up and tail down, or nose down and tail up.



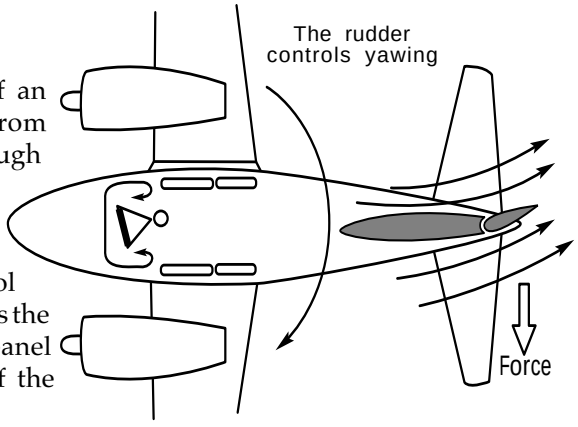


To control pitch, movable hinged panels called elevators are on the rear edge of the horizontal tail or stabilizer. The elevators are linked by rods, cables, and wires to the control wheel or control stick in the cockpit. The pilot makes the airplane go up or down by moving the elevators up or down.

Pulling back on the control wheel or stick raises the elevators and forces the tail of the airplane down. This action points the airplane's nose up and it begins to climb. When the control wheel or stick is pushed forward, the elevators are lowered, raising the tail. This action causes the nose to point down and the airplane loses altitude.

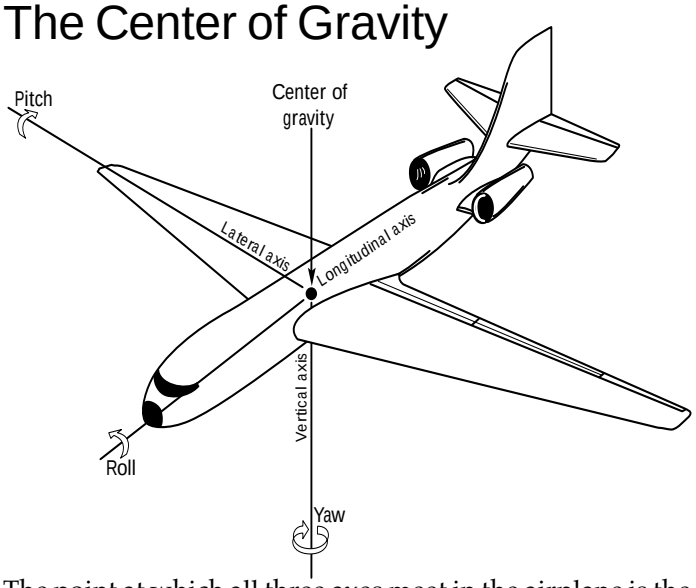
Yawing

The vertical axis of an airplane extends from the top down through the bottom. The movement around this axis is called **"yawing."** To control yawing the pilot uses the rudder, a hinged panel on the rear edge of the vertical tail.



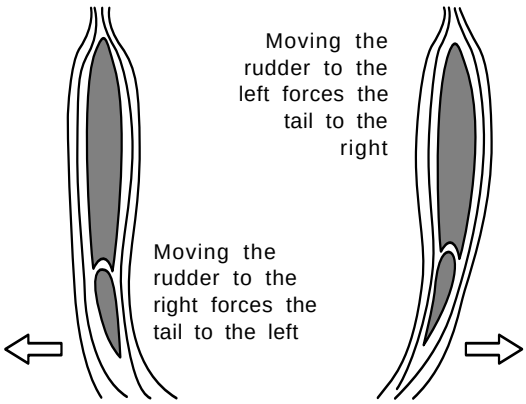
The pilot moves the rudder right or left by pressing either the right or left rudder pedal with his or her feet. Moving the rudder to the right forces the tail of the airplane to yaw to the left and the airplane begins heading toward the right. Pressing the left pedal moves the rudder to the left, and this forces the tail to yaw to the right and the airplane begins heading to the left.

The Center of Gravity



The point at which all three axes meet in the airplane is the **Center of Gravity (CG).** This is where the total weight of the airplane is concentrated and it is balanced. (Balance a stick or ruler on your finger horizontally and you have found the center of gravity.)

All three of these axes must be kept under control to fly the airplane safely and keep it stable. To turn an airplane properly, pilots use the controls for all three axes: **ailerons, rudder,** and **elevators.**



Controls in the Cockpit

The airplane controls operated by the pilot are located in the **cockpit,** usually at the front or the nose of the airplane.

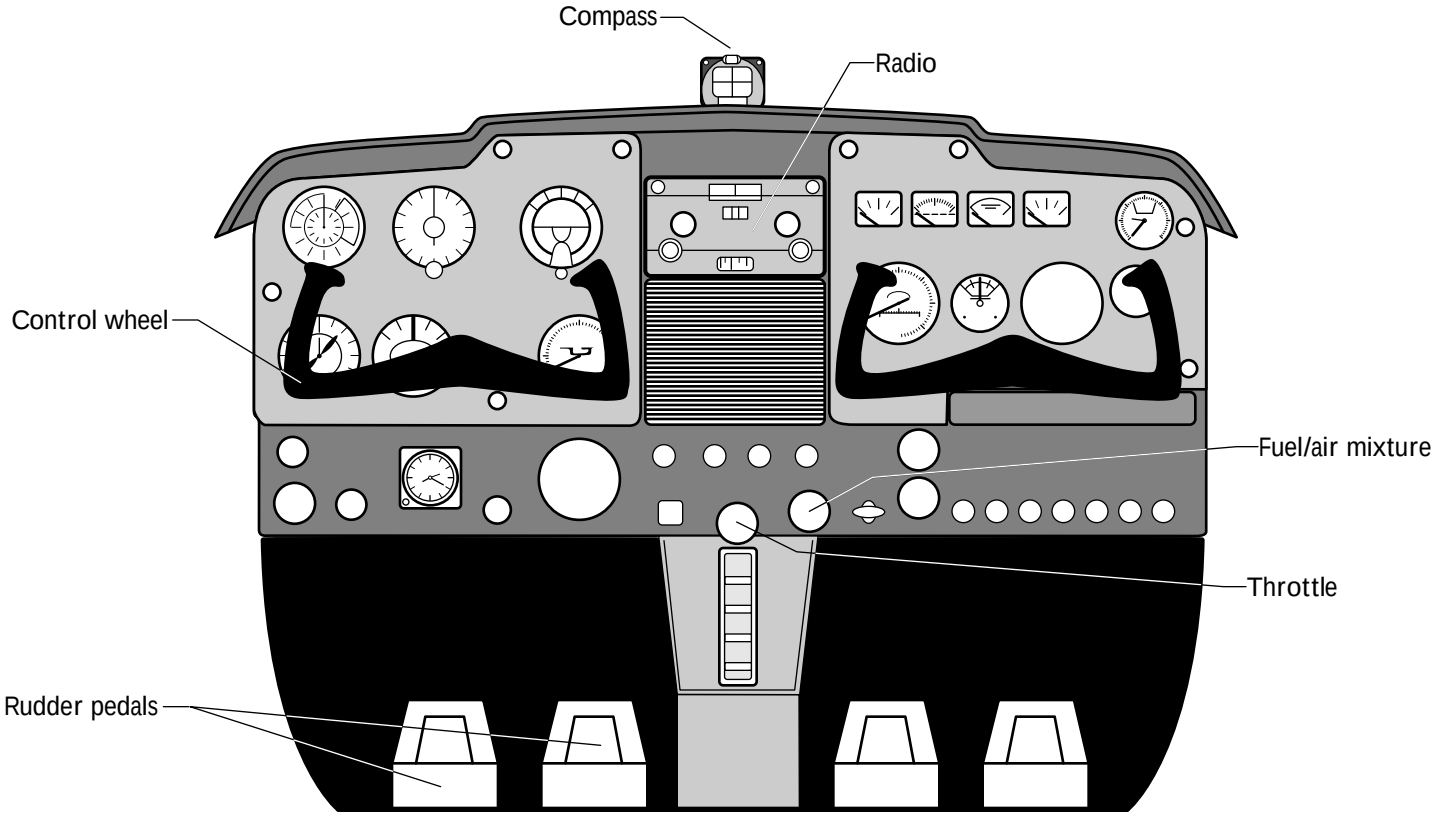
In front of the seats is an **instrument panel** and radio equipment. The instruments give the pilot information about the speed and temperature of the engine, oil pressure, amount of fuel in the tanks, and the direction the airplane is flying. The radio and earphones let the pilot talk to airport control towers, weather stations, and other airplanes.

Most private airplanes have a control wheel on the instrument panel. Turning the wheel left and right operates the ailerons on the wingtips for roll control. Pushing the control wheel forward or pulling it back operates the elevators at the tail for pitch control. The pedals that move the rudder (at the tail) are located on the floor and are operated by the feet. The rudder pedals control yaw.

Instead of a gas pedal, like there is in a car, airplanes have hand throttles. The throttle is a knob or lever at or near the instrument panel. To control the speed of the engine, the throttle is usually pushed in or pulled out. The throttle controls the amount of fuel being used by the engine.

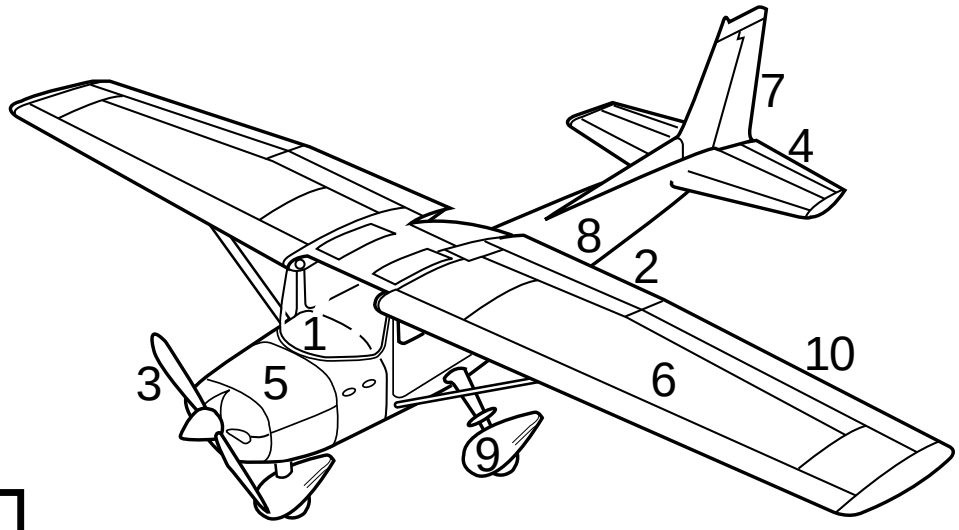
Next to the throttle is a knob that controls how much air is mixed with the fuel as it goes into the engine. Because of gravity, as the airplane goes higher and higher, the air weighs less and less and the airplane needs a different mixture of air and fuel to run smoothly.

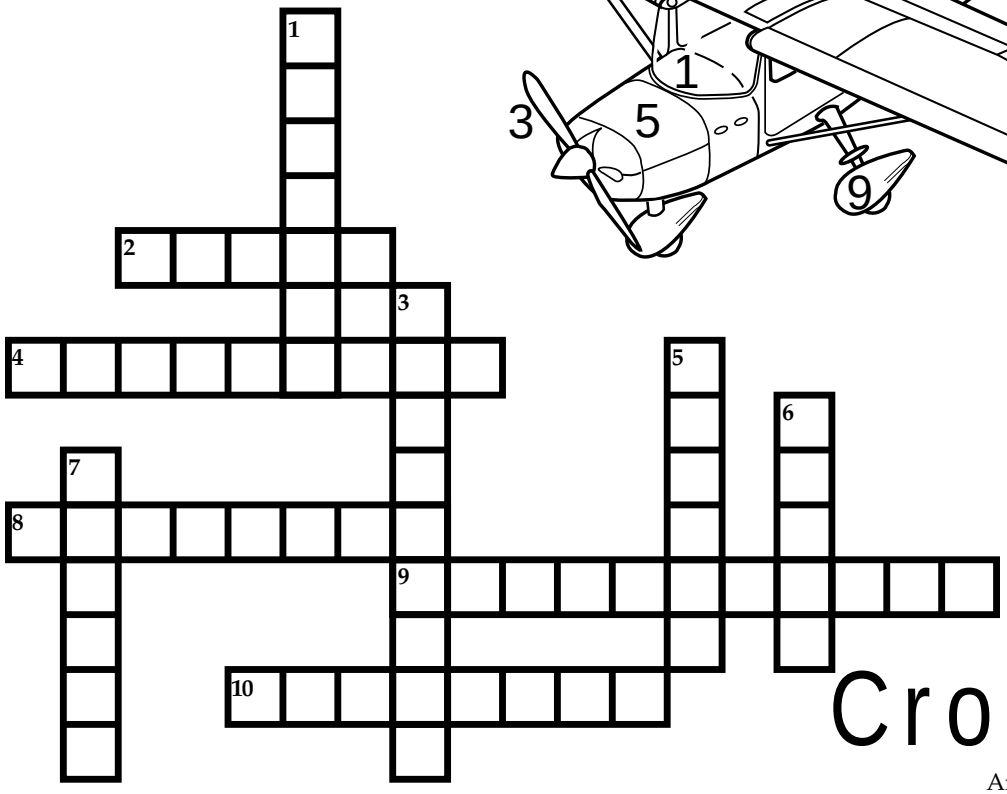
Another important instrument usually found in every airplane is a compass. They show the pilot what direction he is flying: north, south, east, or west. In some airplanes, compasses are located in the instrument panel. On our airplane, and on many other small airplanes, it is mounted on top of the instrument panel.



Instrument panel

Airplane Parts Crossword





Answers on page 28

Across

2. These wing sections move to help the airplane fly slower.
4. This horizontal part of the tail makes the airplane go up and down.
8. This part forms the main body of the airplane.
9. This structure supports the airplane while on the ground.
10. These sections on the outer part of the wings help the airplane turn.

Down

1. The instruments and controls are located here.
3. This turning blade on the front of an airplane moves it through the air.
5. This device turns the propeller.
6. These parts provide lift and support the airplane while in flight.
7. This vertical part of the tail controls the sideways movement of the plane.

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page

Firsts In The Air

Marta Bohn-Meyer is one of the two flight engineers that fly in the NASA SR-71. She is the first woman ever assigned as an SR-71 crew member. The SR-71s can fly three times the speed of sound (about 2,200 miles an hour). The Dryden Flight Research Center is using the SR-71s to obtain high-speed, high-altitude data to help design future aircraft, including future civilian transports, and for high altitude atmospheric research.

Marta graduated in 1979 from Rensselaer Poly–technic Institute in Troy, N. Y., with a bachelor of science degree in aeronautical engineering. She began working at NASA's Dryden Flight Research Center in 1979 as an operations engineer and has worked on a variety of research projects. These projects have included flight tests of space shuttle thermal protection tiles, using a NASA F-104 aircraft, and work on the F-16XL laminar flow project, of which she is now project manager.

Born in Amityville, N. Y., Marta is an FAA-certified flight instructor and is a competitive aerobatic pilot. She and her husband, Bob, who also works at NASA, built their own aerobatic airplane, which they both fly in competition.

Complete the statements below.

The first letters of the answers spell **t-e-s-t.**

1. One of the projects Marta tested was the **t**_____ _____ _____ on the space shuttle.

2. Marta is one of two flight **e**_____ that fly in the SR-71.

3. The SR-71 can fly three times faster than the speed of **s**_____.

4. Marta earned a bachelor of science degree in aeronautical engineering from a school in **T**_____, New York.

Suited for Safe Flight

Before a NASA pilot takes off in an airplane, he or she must put on special equipment.

- The **helmet** and **visor** protect the pilot, not only in the case of emergency, but also from the glare of the sun. The helmet can have speakers within it so the pilot can hear instructions from the control tower on the ground, as well as radio signals from other airplanes.

- The **oxygen mask** plugs into a port inside the cockpit to give the pilot breathable air when he or she is flying at high altitudes where the air is thin. The mask also can have a microphone in it to allow the pilot to talk on the radio.

- The **parachute** is used by the pilot if he or she has to eject in an emergency. The **harness** worn by the pilot attaches to the parachute pack and ejection seat.

- The **flight gloves** and **boots** help protect the pilot in case of fire.

- The **anti-G suit** prevents the pilot from "passing out" in extreme maneuvers

Learning To Fly

To become a pilot in the United States, you must be at least 16 years old. Second, you have to be in good health. And third, you have to be able to read, speak, and understand English. You can apply for a student pilot certificate if you are at least 16 years old. When you're 17, you can apply for a private pilot certificate. The FAA (Federal Aviation Administration) requires everyone who wants to become a pilot to pass a routine medical exam every two years. Allowances are made for many physical limitations. For example, it is OK for a private pilot to wear glasses or contact lenses. Pilot training has two aspects: ground training and flight training. Ground training takes place on the ground. It covers flight rules and regulations, flight planning, navigation, radio procedures, and weather. In the next phase, flight training, you learn to fly by actually controlling the airplane yourself. Under the supervision of a certified flight instructor you learn how to takeoff, land, and fly cross-country (from your home airport to another airport and then back again). Most people receive their private pilot certificate after about 55 hours of flight time, including time spent with an instructor (dual time) and time spent flying alone (solo time). Training will include some night flying, some instrument flying (using the instruments to help fly the airplane instead of looking out the cockpit), and cross-country flying. The minimum time required by federal regulations is 35 to 40 hours of flight time, depending on the type of school you attend. No test is required for a student pilot certificate, however, you must pass a written and flying test to receive your pilot's license. Once you have your license, you'll have access to a whole new world. You'll be a master of our century's most distinctive and rewarding art — flying.

Fly a Perfect Loop!

The loop is one of the basic four aerobatic maneuvers (loop, roll, spin, and hammerhead or stall turn), and was one of the first aerobatic maneuvers successfully completed. Aerobatic pilots often use the loop in combination with other maneuvers to create complex three-dimensional patterns in the sky.

Flying a basic loop is easy. Flying a perfect loop, on the other hand, is nearly impossible. Most loops flown by beginners, or in less powerful airplanes, come out egg-shaped. The airplane flies through the beginning and the end of the loop at higher speed, so the bottom is rounder and larger. But by the time the airplane reaches the top of the loop, gravity and the high drag of maneuvering have slowed it considerably, so it loops more tightly at the top.

If the pilot keeps the airplane from drifting right or left during the loop, the airplane will tremble slightly at the bottom of the loop as it flies through the turbulence created by its propeller at the start of the loop.

Make this flip book — and "fly" a perfect loop, "flight" after "flight."

Activity:

1. Make two copies of these pages by tracing, duplicating, or photocopying. (Two copies make a much smoother animation.)

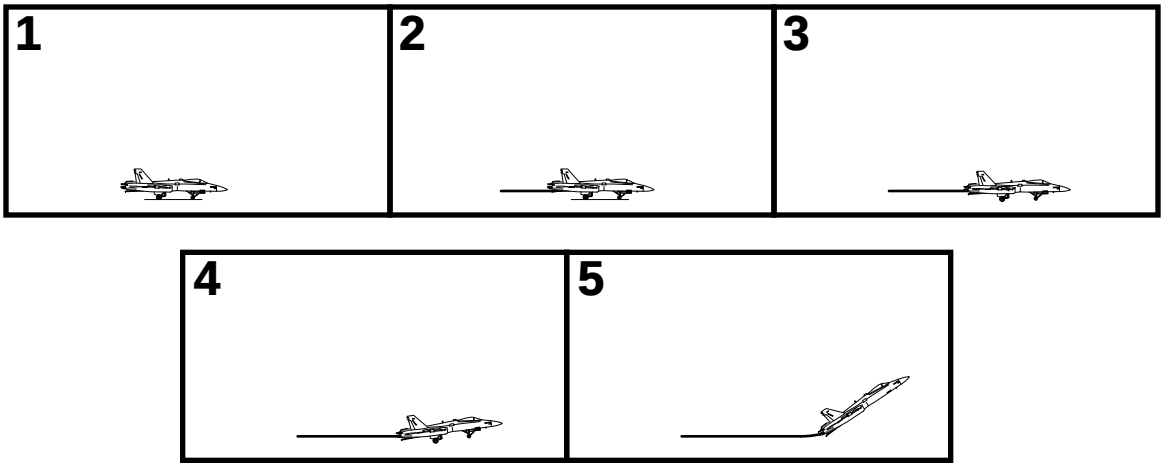
2. Carefully cut the numbered pictures apart along the solid lines.

3. Stack the pictures in sequential order, with the two copies of Picture one (1) on top, the two copies of Picture two (2) next, and so forth.

4. Tap the right edge of the stack of pictures on a hard flat surface to align them. Be sure that the right edge of the stack is as even as possible.

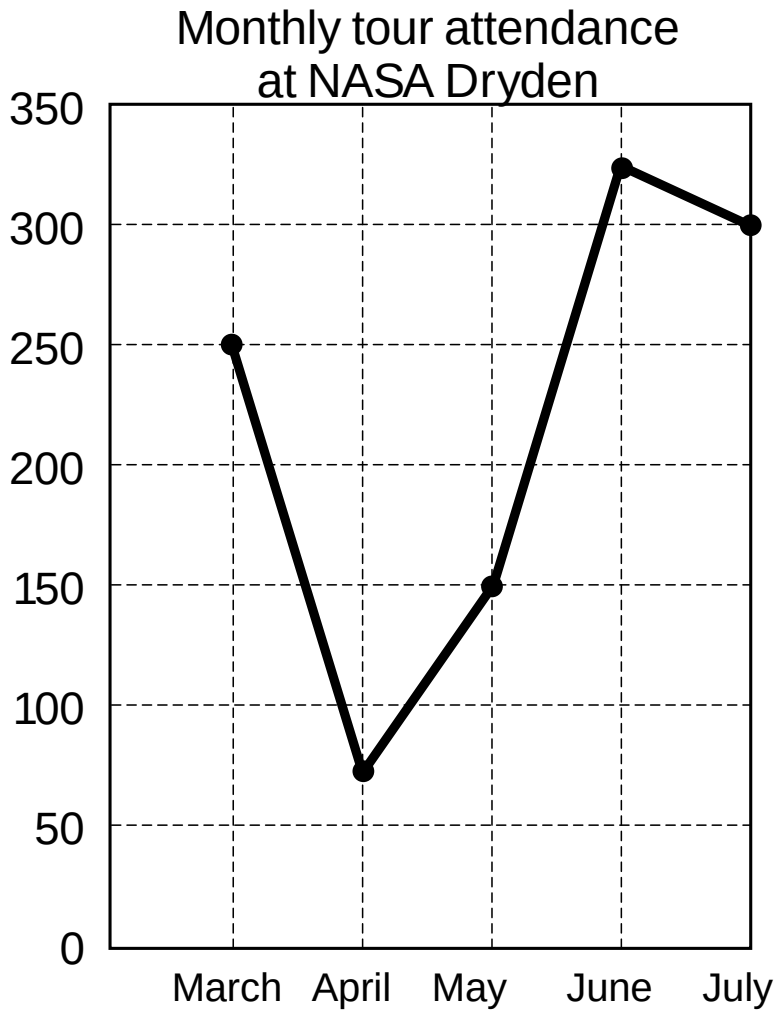
5. Staple the stack on the left margin. Try to keep the stack from shifting while stapling.

6. Hold the left side of the flip book in one hand. Flip the pages between the thumb and index finger of your other hand to see how an airplane performs a loop.



Boxes 6-30 art

Reading a Line Graph



Answer these questions about the line graph.

1. About how many people went on the tour at Dryden in June?

2. Which month had the lowest attendance?

3. During which month did about 250 people go on the NASA tour?

4. During which months was the attendance greater than 250 people?

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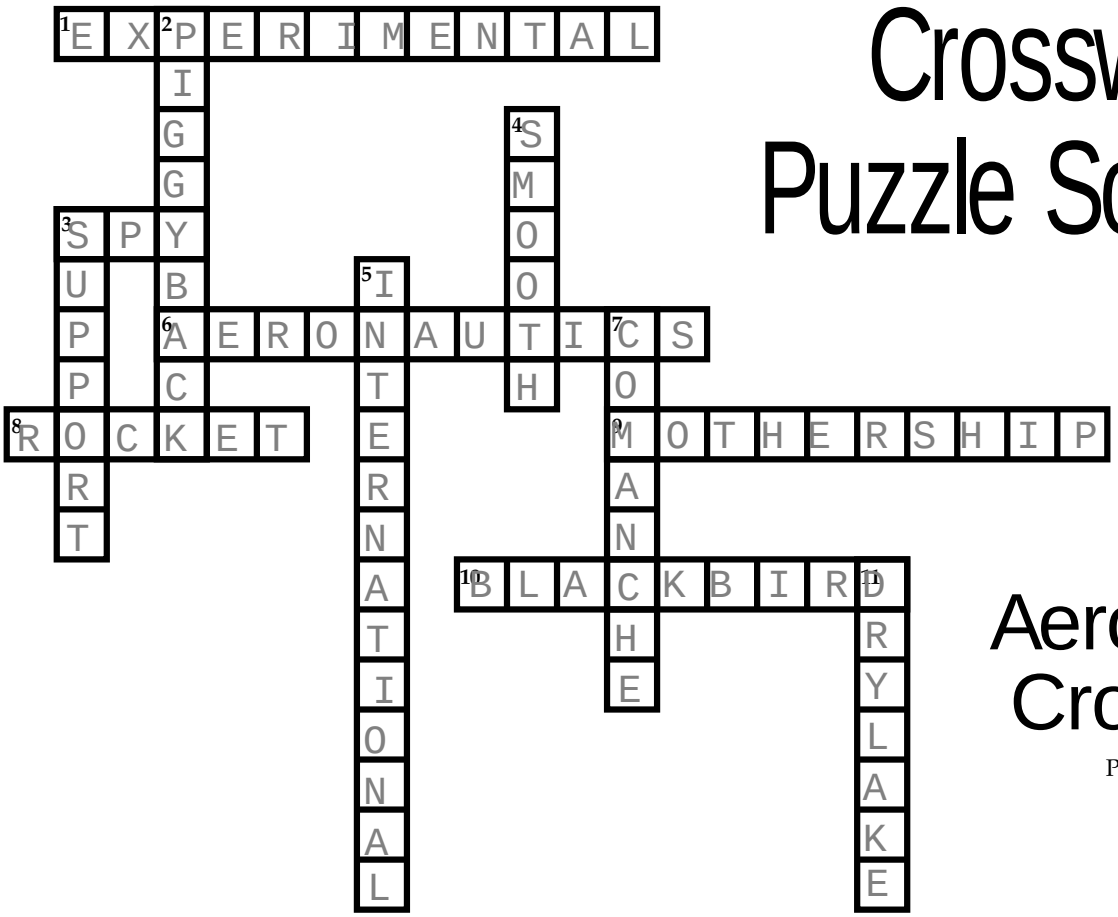
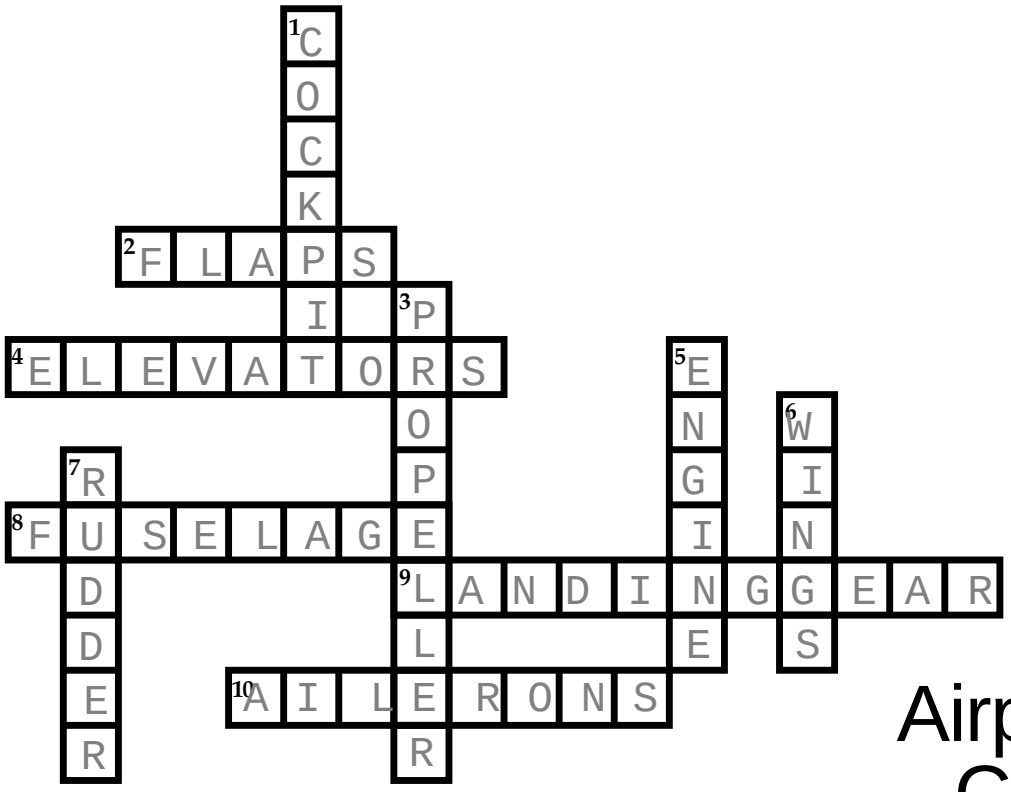
Crossword Puzzle Solutions



Aeronautics Crossword

Puzzle on page 6



Airplane Parts Crossword

Puzzle on page 19

F-15 Paper Cutout

F-15 Paper Cutout
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